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Use of Sawdust in the Composition of Plaster Mortars

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Abstract

After 1990, the management of large amounts of wood and sawdust waste has become a problem of major importance in Romania. This requires the diversification of their material and energetic use. In this context, the construction industry has wide perspectives for their material use. This study contributes to the existing range of building materials that use wood and sawdust waste. It presents a new modality for recycling sawdust in order to obtain an ecological plaster mortar. Five sawdust plaster mortar recipes and the methods for their preparation are presented. The research led to the determination of the optimal proportion for the manufacture of sawdust plaster mortar, as well as to the identification of problems raised by its manufacture. The technology for the production of sawdust mortar is non-polluting and does not involve a high energy consumption.

Keywords: sawdust, recycling, plaster, ecological mortar

1. Introduction

Wood is a natural, abundant and renewable material, which is available in large amounts in Romania. Due to its physico-mechanical properties and to its multiple technical and structural advantages, wood was and will continue to be one of the main building materials [2].

After 1990, the exploitation of wood in Romania has developed unprecedentedly, through the creation of a great number of trade companies whose activity consists of wood processing and timber production [6].

Timber factories are the most important producers of wood waste ranging from sawdust to wood chips.

The storage of this type of waste under inadequate conditions has a considerable environmental impact.

The duration required for sawdust to turn into a fertilizer ranges between 15 and 25 years and consequently, it is not suitable for agriculture. Sawdust deposited on the banks of waters is mobilized by rain and thus penetrates surface waters and becomes a stress factor for aquatic animals, while sawdust deposited in the fields severely affects the quality of the soil, which can no longer be used for agriculture [6].

Sawdust and timber, if inadequately stored, are sources of fire (fig. 1).

Wood waste pollution leads to the removal from the production circuit of land where vegetation no longer grows or reestablishes with difficulty, to the alteration of the normal circuit of surface waters, to the propagation of wood dust in the atmosphere. As a result of the high amounts of sawdust that are currently produced from various wood species and as a result of the negative environmental impact, the “National Waste Management Plan” requires the energetic or material use of sawdust waste [8]. Wood sawdust has a series of particularities such as: low specific weight, it is hygroscopic, mean calorific power depending on the wood species [6].

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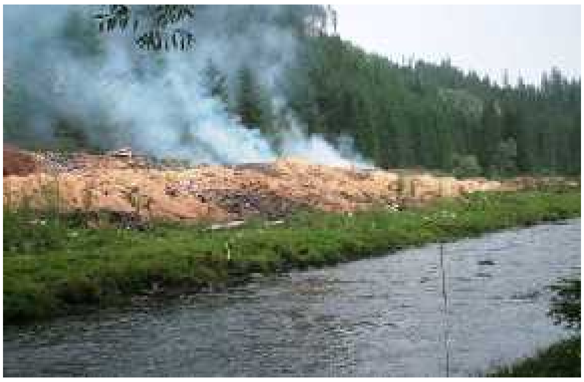


Figure 1. Sawdust dump [7]

Taking into consideration the calorific power of sawdust and wood waste, these can be an important energy source. The possibilities of **energetic use of sawdust** are firing in large capacity industrial ovens, firing in small stoves for heating the houses, and the manufacture of sawdust briquettes that are easy to ignite and leave very little ash [6].

Currently, the **material use of sawdust** and wood chips mainly refers to:

- the manufacture of wood fiberboard, such as:
- three-layer boards, with cement fiberboard facings and a polystyrene core, combine the characteristics of the two materials and are used for the thermal insulation of reinforced concrete elements [4];
- three-layer boards, with cement fiberboard facings and a glass wool core, combine the characteristics of wood and glass wool, being used for the thermal insulation of reinforced concrete elements [4];
- cement fiberboard, made from wood fibers bonded with a cement paste. They are used both for siding and for the execution of lost casings for exterior concrete walls [4];
- the manufacture of light concrete with sawdust aggregate subjected to an undemanding strain. Sawdust contains considerable amounts of water soluble impurities that delay the hydration and setting of the cement paste. In order to neutralize the sawdust impurities, physico-chemical treatments are required, which considerably increase the price of the concrete obtained in this way [5];
- compost for agriculture – in small amounts, because it ensures good soil permeability and friability [6];
- decontamination of lands infested with oil substances due to the high absorption capacity of sawdust, which is subsequently collected and incinerated [6].

Sawdust is a good thermal and sound insulator and its low embodied energy and low cost, recommends it for the manufacture of thermal and sound insulating materials [3, 9]. The research on the use of sawdust waste for the manufacture of ecological mortars fits into this context.

2. Material and method

The recycling of sawdust in the building materials industry is an efficient solution, with beneficial effects both for the construction industry and for environmental protection and improvement, allowing at the same time for the protection of natural resources.

The materials used for the experimental part are plaster, sawdust, and water. Their characteristics are shown in Table 1.

Table 1. Characteristics of materials

Material	Grinding fineness [mm]	Density [kg/m^3]	Refined bulk density [kg/m^3]
Plaster	< 0.2	2381	738
Sawdust	< 0.2	1724	305

The study was carried out in five sawdust mortar recipes, whose physico-mechanical characteristics were compared to those of the standard sample.

The recipes are shown in Table 2.

The method for the manufacture of sawdust waste mortar consists of:

- preparation of waste – because sawdust contains considerable amounts of water soluble impurities, their neutralization by physico-chemical treatments is required [1]. This is why sawdust was pretreated by water soaking and washing before mixing, to make sure that the auxiliary materials in sawdust would not affect the setting of mortar.
- weighing of the materials;
- homogenization of the components with the mixer;
- casting of test samples (4x4x16 cm prisms and briquettes).

Physico-mechanical and fire behavior determinations were performed in test tubes cast and stored according to standards during this period.

Table 2. Mortar recipes

Recipe		Plaster [g]	Water [cm^3]	Sawdust [g]	Sawdust [%]
Standard sample		100	66	-	-
I	5% sawdust	95	70	5	5
II	10% sawdust	90	73	10	10
III	15% sawdust	85	76	15	15
IV	25% sawdust	75	86	25	25
V	50% sawdust	50	140	50	50

3. Results and Discussions

The physico-mechanical characteristics were determined according to the standards in force, using the equipment of the Building Materials Laboratory of the Civil Engineering Faculty of Cluj-Napoca. The following physico - mechanical characteristics were determined in the test tubes: the apparent density of set mortar, tensile, bending and compressive strength, adhesion to the support layer and fire behavior. The **results** obtained following the physico-mechanical determinations are synthesized in Table 3.

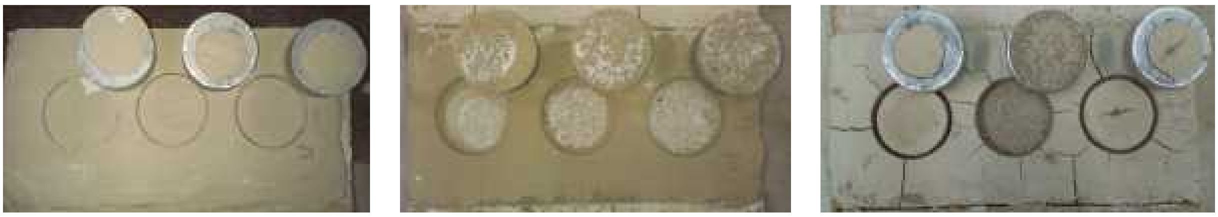
Table 3. Technical characteristics obtained

Recipe		Apparent density [kg/m^3]	Adhesion to support layer [N/mm^2]	Tensile strength [N/mm^2]	Bending strength [N/mm^2]	Compressive strength [N/mm^2]
Standard sample		1098	0.33	1.91	5.91	9.20
I	5% sawdust	931	0.30	0.51	1.43	2.35
II	10% sawdust	893	0.25	0.50	0.88	1.75
III	15% sawdust	837	0.14	0.32	0.49	0.70
IV	25% sawdust	723	0.00	0.00	0.33	0.60
V	50% sawdust	466	0.00	0.00	0.00	0.00

Table 3 shows, by comparing the values of the results obtained with the values of the characteristics of the standard sample, that only the first three recipes deserve to be taken into consideration; recipes IV and V are eliminated because of the very poor results regarding the physico-mechanical characteristics.

It was found that for recipes containing more than 10% sawdust, the increase of the sawdust proportion determined a decrease of the volume of the cast test samples, so that in recipe V there was a reduction of up to 22% compared to the initial volume.

The contraction of the test samples was due to the decrease in the volume of sawdust granules after the evaporation of water. The replacement of plaster with sawdust had a strong effect on the **apparent density** of mortar. Thus, in recipe I with 5% sawdust, apparent density decreased by 15%, and in recipe III with 15% sawdust, it decreased by 23.5% compared to the standard recipe. From the point of view of **adhesion to the support layer** (fig. 2), a decrease in its values was found with the increase of the sawdust proportion, but this reduction remained within the acceptable range of values.



5% sawdust 10% sawdust 15% sawdust

Figure 2. Adhesion to support layer

In fig. 2, it can be seen that the sample containing a thin mortar layer with 15% sawdust cracked.

This can be explained by the great influence of humidity on the volume of sawdust granules, which diminish their volume after drying.

This phenomenon causes visible fissures and cracks in the mortar in the case of thin layers.

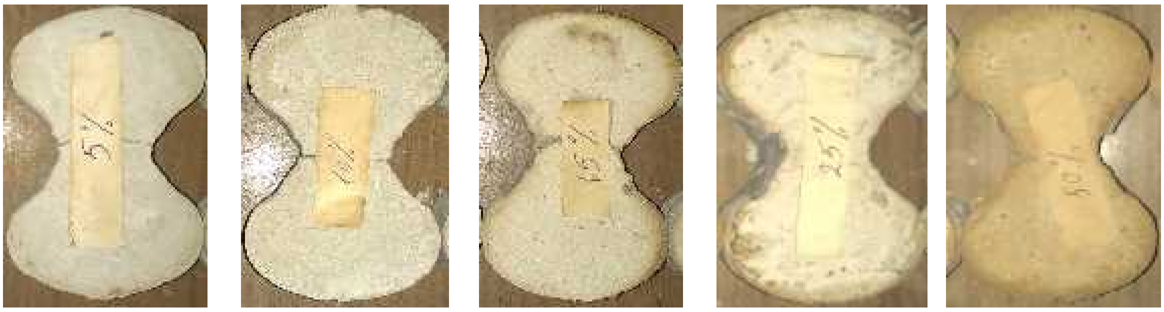
The fire behavior of mortar

- Within 60 seconds of gas lamp burning, the mortar underwent the following stages:
- in the first stage, there was an increase of temperature on the surface exposed to the direct flame, up to the ignition of surface sawdust granules;
- in the second stage, even if the direct flame was removed, the firing of surface sawdust granules continued until their carbonization.

From the point of view of the firing behavior of mortar, after 60s, the formation of a protective carbonized layer on the surface found in direct contact with the flame was noted. When the carbonized layer was reexposed to the direct flame, this area of the material did not reignite and no smoke emissions occurred.

After 300s, the mortar exposed to the direct action of the flame in the burner (~1000°C) allowed to place the hand on the opposite side. This demonstrates that the material is a good thermal insulator.

In terms of **tensile and bending strength** (fig. 3), there was a significant decrease, compared to the standard sample, with the increase of the amount of sawdust in the recipes.



5% sawdust 10% sawdust 15% sawdust 25% sawdust 50% sawdust

Figure 3. Briquettes – tensile strength

From the point of view of **compressive strength**, the manufactured mortars fit into the following classes of plaster mortars:

- the plaster mortar with 5% sawdust and 10% sawdust falls into class CSII;
- the plaster mortar with 15% sawdust is categorized as class CSI.

4. Conclusions

Following the research on the manufacture of ecological sawdust plaster mortars, it was found that the optimal proportion of sawdust in the mortar recipe varied between 5% and 10%.

In recipes with more than 10% sawdust, the volume of the cast test samples decreased with the increase of the sawdust proportion, so that in recipe V with 50% sawdust, there was a reduction of up to 22% compared to the initial volume. The contraction of the test samples was due to the decrease in the volume of sawdust granules after the evaporation of water.

For the same reason, in thin plaster mortar layers, starting with 15% sawdust content, fissures and cracks occur in the mass of the set mortar. In order to reduce these effects, the introduction of lime is required, which increases the setting time of plaster to a value close to that of the drying time of sawdust.

The obtained mortar has an apparent density of about 900 kg/m^3, which places it depending on compressive strength in class CS II.

The technology for the production of sawdust mortar is non-polluting and does not involve a high energy consumption.

An extremely important characteristic of mortar is its sound and thermal insulation capacity due to high porosity.

The experiments performed regarding the fire behavior of mortar show that it is not susceptible to ignition under the action of an open flame, and it has a high degree of thermal insulation.

The obtained mortars can be used as interior plaster mortars for the improvement of the thermal and sound insulation of houses.

The results of this study open the way to the manufacture of new building materials allowing for the material use of sawdust.

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